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Introduction: Working with Diagrams

Lukas Engelmann, Caroline Humphrey and Christos Lynteris

Abstract:

The introduction presents the issue's focus on 'working with diagrams' and explains the editors' choice to point beyond semiotic, cognitive, epistemic or symbolic readings of diagrams. To sharpen this perspective, we introduce recent research on diagrams and diagrammatic reasoning in anthropology, science and technology studies, the history of science and medicine, and in architecture. With this broad field in mind, we approach diagrams as suspended between imagination and perception, as objects with which work is done and as objects that do work. The issue collects an innovative and interdisciplinary set of theoretical, historical as well as practical propositions to engage with this question. Contributions to this issue probe diagrams for the work they do in the development of disciplinary theories, investigate their reworking of questions of time and scale and ask how some diagrams work across fields and disciplines. Other authors have shifted the perspective to their own work with diagrams, reflecting on the practice and performative nature of diagrammatic reasoning in their respective fields and disciplines. Taken together, this special issue moves beyond an understanding of diagrams as mere inscriptions of objects and processes and proposes instead re-evaluation of diagrammatic reasoning as the work that is carried out with, on and beyond diagrams.

Key Words: diagram, diagrammatic, work, reasoning, interdisciplinarity

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“There can be”, Martin Jay argues in a review of Bender and Marrinan’s *The Culture of Diagram*, “no question that the role of the humble diagram in many different fields has been slowly earning recognition for some time” (2010-2011: 158). From studies of evolutionary tree diagrams (Catley and Nivick 2008; Gontier 2011) or the use of diagrams in semiotics (Stjernfelt 2000) to explorations of their impact on Euclidean geometry (Norman 2006; Miller 2007), to visualising Foucault’s abstract machines (Deleuze 1988; Elmer 2003) or exploring Deleuze’s philosophy (Knoespel 2001; Teyssot 2012; Zdebik 2012) historians, philosophers, linguists, geographers and STS scholars have over the past twenty years been dissecting and interrogating the diagrammatic heart of a number of sciences and disciplines. Of particular importance in these studies has been the examination of diagrams as epistemic images, which in the definition of Christoph Lüthy, and Alexis Smets (2009: 399) refers to “any image that was made with the intention of expressing, demonstrating or illustrating a theory” (for a recent approach see: Drucker 2014). At the same time, the interest shown by cognitive science in the nature of diagrammatic representations since Larkin and Simon’s classic paper on the subject (1987) has led to a proliferation of studies of “diagrammatic cognition”. In anthropology itself new studies of the use of diagrams both by anthropologists (Bouquet 1996, Ingold 2007) and others (Bonelli 2015, Hallam 2018, Lynteris 2017) are markedly different from older reflections on the medium (e.g. Burr and Gerson 1965, Hage and Harary 1983) that took diagrams to simply be tools for visualising data and data relations, but which could not in themselves add information. Moreover, as Matei Candea stresses in his contribution to this special issue, anthropologists have recently resumed their own use of diagrams “not simply as illustrations, but as key steps in argument.”

These new studies across the discipline approach diagrams in a new ontological space, where as Lorraine Daston (2014: 320) has argued, “the distance between presentation and representation” is collapsed. Perhaps a famous literary parable summarises this turn best. In Stefan Zweig’s acclaimed novella *A Chess Story*, Dr B tried to salvage his sanity from the torture of “nothingness” to which he is subjected by the Gestapo by rehearsing in his head 150 historical chess matches whose diagrams were contained in a periodical he managed to steal from his torturers. When, years after his release, he comes across a real chess match on an ocean liner bound for Buenos Aires, he is both mesmerised and disoriented: “I stared at the board as if magnetized and saw my diagrams, my knight, rook, king, queen and pawns as real pieces cut from wood; to understand the situation in the match I first had to transform it back from my world of abstract notation into that of movable figures” (Zweig 2013: 93). In his examination of the work of diagrams in architecture, Anthony Vidler (2000: 6) has argued that, “Operating between form and word, space and language, the diagram is both constitutive and projective; it is performative rather than representational”. A good example for this might be found in a recent body of STS scholarship on the performativity of economics which has looked in particular at the influence of diagrams and charts, both digital and analogue, in the forecasting of trends and price indexes in economic reasoning (Callon 2006, Mackenzie 2008). In this field, “chartism” has been coined by Alex Preda to describe a specific form of expertise, in which shapes and characteristic curves of diagrams, like “breaking gaps, flat bottoms, sauce bottoms, falling flags” have come to populate the distinctive vocabulary of economists (Preda 2007: 41). In this case, the economists’ work with diagrams has come to shape the identity of their discipline as

much as it has impacted the evaluation of economic risks and chances. Yet, at the same time, as Yann Giraud (2014) has shown, the work of economic graphs, like Laffer curves, has become the object of critical examination and even parody by economists themselves (e.g. Gardner 1981), pointing to the complex and indeed reflexive working of diagrams within professions and disciplines that employ them.

Our focus on “working with diagrams” in this collection arises from the need to go beyond the semiotic, cognitive, epistemic and symbolic reading of these visual devices, which pervades the social sciences and the humanities. But why is the idea of “work” so important when it comes to diagrams? Jay (2010-11: 158) has argued that, “the diagram has been more of a hybrid between ideas and perceptions”, acting as what, following historians of science Lorraine Daston and Peter Galison (1992), we may call a “working object.” Such objects “never duplicate a reality external to them, nor are entirely the result of pure imagination, but somehow fall productively between the two” (Jay 2010-11: 158). So what is the work that this working object does? And why is this “work” rather than just utility or efficacy? In other words, why is this collection about working with diagrams and not simply about using them?

The contributions to this special issue emphasize that diagrams inhabit a mediating space between representation and prescription, words and images, ideas and things, theory and practice, abstraction and reality. As many have pointed out before, diagrams find a strong place in key moments of scientific, technological and intellectual innovation leading to everyday uses in all spheres of social, political, economic and cultural life. Conversely, employed across the disciplines as thinking tools, they hold the promise of transforming abstract ideas into graspable images and translating the unseen

into intelligible and actionable form. This issue explores such transformations in relation to time (e.g. change or evolution as diagrams are copied repeatedly), scale (e.g. tiny anthropological samples used to model large theories) and cross-field transfers (e.g. diagrams originating in genetics used in anthropology, or from animation software used in architecture). But rather than attempting to define the dietic capacities of the diagrammatic across disciplines, the contributions of this special issue draw together the work diagrams do in the development of theories. And they focus on the collaborative and cooperative work that scientists, architects or anthropologists carry out with, and on, diagrams. Moreover, we focus on the question of how diagrams have been made to work.

First of all, such a focus on working with diagrams enables us to move beyond representational as well as cognitive approaches. Indeed, it requires us to understand diagrams less as images, and more as visual devices. Let us take the example of the most prolific diagram in Jewish mysticism: the Kabbalist Tree of Life which is generally seen as “mapping the topography of the Godhead, often imagined in terms of four gradually emerging worlds and ten luminous emanations” – i.e. the Sefirot (Chajes 2016). The mapping in place in this diagram elucidates the “order and interconnection” of different emanations and the way in which this in turn forms the cosmos (Ibid). But the Tree of Life is not simply a description of the cosmos for philosophical contemplation – it is a working tool of Jewish mysticism. The leading authority today on diagrammatic aspects of the Kabbalah, Yossi Chajes (2016) gives an illuminating example of this. In his essay “Kabbalistic diagrams in the British Library’s Margoliouth Catalogue” for the British Library, he discusses the 1588 CE manuscript MS 27091 which contains a number of intriguing diagrams. These are of course illustrations of the mystical text, but they are

also more than just that. Take for example the following diagram [Figure 1] where in the centre of each Sefirah is visible a “volvelle”. These medieval astronomical instruments of concentric rotating disks, Chajes argues, “illustrate the fractal [...] concept of the Sefirot” (Ibid). But this is not simply an illustration of a cosmological fact, namely that “each Sefirah contains all ten of the Sefirot” (Ibid). Rather, Chajes (2016) maintains, it has a key practical implication: “The idea of physically manipulating the discs gives tangible expression to the importance of practicing visual variations when contemplating the divine; the structure should be perceived as alive and bearing almost infinite potential” (Ibid).

Figure 1 HERE

For this collection, we take two important aspects from this arboreal mystical diagram. First of all, not all workings with diagrams find their purpose in methods of simplification, schematisation or standardisation. On the contrary, the contributions to this issue stress that the diagram might as well insist on the complexity of epidemic, anthropologic or genetic configurations, that their production allows to push beyond the limits of theoretical frameworks and their mobilisation is accompanied by translations and interferences, in which clarity is lost rather than increased. Second, the scholarship on diagrams has predominantly focused on diagrams as products of a thought process, a result of a research endeavour or the disseminated abstraction of a discovery. By contrast, our focus on the workings of diagrams enables us to focus also on the often-ephemeral nature of diagrams within the processes of observation, analysis, research and theorizing.

Our contributions stress the co-production of epidemic theory between geographic sketches and understandings of disease, they extrapolate from spatial interior configuration to the diagrammatic conceptualisation of the mind and demonstrate the sheer multiplicity of concepts in the repeated iteration of diagrammatic drawing. To this end, the essays of Spankie and Steadman in this special issue have integrated the performative nature of diagrams and diagrammatic reasoning into the development of their papers. Both of their arguments shift between a reading of diagrams and a diagrammatic visualisation of readings.

In her contribution, Ro Spankie reads the diagram as an invitation to shift registers from theories about the mind to the design of the interior space of Freud's study and consulting room. With reference to Mary Douglas (1991), Spankie approaches Freud's interior as one which "exists in time and has aesthetic and cultural dimensions" and which folds the spatial coordinates of rooms, in which psychoanalytic work is carried out into the interior of the mind, whose structures Freud aimed to work out. As an architect herself, Spankie works in her contribution with diagrams to trace the processes of translation and extrapolation between physical and psychological spaces. She emphasizes that, "as a technique, diagramming shifts the emphasis from physical form or appearance to latent structure." Following these implicit structural connection and associations, Spankie reconstructs the genealogy of Freud's psychoanalytical mind through a close reading of a range of diagrams, diagrammatic practices and diagrammatic translations. On the one hand, this enables a different reading of Freud's work, in which the significance of spatial metaphors becomes visible. She suggests understanding Freud's descriptions of "psychoanalysis as a process of ordering one's thoughts in the

same way as one might order one's things in a cluttered or disorderly interior."Spankie re-engages with the kinds of visualizations diagrams enable, when she demonstrates the imprint of Freud's spatial arrangements on his diagrammatic representations of "dream structure", to propose the diagram as a principle, through which the invisible mind is rendered visible as a contingent visual analogy.

These cross-readings of diagrams in between spatial arrangements and theories of the mind circle around a theme that Philip Steadman too picks up in his epilogue to this collection: the relationship of ornament and order in and through diagrams. But Steadman asks how this relation is configured in diagrammatic processes of copying of designs. He focuses on a technique of copying as applied by researchers investigating the capacities of visual memories. Rather than the expected deterioration of form and shapes towards chaos, serial copying of drawings expose "some tendencies towards schematisation." From ornament to order, through repeated copying of drawings in experimental setups, it appears that a tendency towards diagrams can be observed. In experiments that Steadman carried out himself, pictures were "flattened out", objects were reduced to their boundaries, topological relationships preserved and only distances and angles changed. Without jumping to conclusions, Steadman argues that these results might indicate a diagrammatical way of thinking and of a general diagrammatic tendency from ornament to order.

The mainstream of studies of diagrams places the work of diagrams in the realm of schematisation or simplification of complex processes in or theories about the world. Historians of science have long unpacked the use of diagrams as reductive representations of the cosmos (Kusukawa and Maclean 2006), as popularised schemes of

complex physical models or as accessible demonstrations of chemical processes (Eddy 2014). The field has looked at diagrams usually through the lens of the material culture of scientific practice and has largely been influenced by Bruno Latour's considerations of inscription (1999: 307-8). As a result, diagrams have been addressed as a type of scientific iconography including tables, graphs, chemical formulae, maps and other abstract two-dimensional representations, which have been mobilised by scientists to transform a scientific object into paper.

While much of the recent scholarship on the history of diagrams in science appear to follow Latour's proposition, more recent work on "paper tools" has begun to emphasise a line of inquiry more comparable to the goals of this special issue. Beginning with the work of Ursula Klein (2003), paper tools and paper technologies were approached in the performative arrangements of laboratories or in the post-war teaching of physics as malleable, multiple forms, which incite a myriad of uses and lay ground to a complex, contingent "diagrammatic reasoning", for example, in the educative and multivalent production of Feynman diagrams in theoretical physics (Kaiser 2005: 18). Contrary to Latour, Kaiser shows how the educative work physicists have done with diagrams served to draw theories apart, rather than bringing things together. The perspective cultivated in recent history of science and knowledge perceives diagrams not as reductive representations of a scientific object, but focuses instead on the "fleeting, undetectable intermediates" that diagrams have produced for example in the history of chemistry (Nye and Weiniger 2018:5) and on the productive, creative and explorative elements of the formal and data-driven reasoning of diagrammatic practices, tools and instruments.

A similar perspective has been developed in the recent historiography of paper technologies in clinical reasoning, identifying the forms, tables, graphs and diagrams that organise pathological discourse, not only as instruments of standardisation and formalisation, but also as technologies which sustain and support narrative practices and enable a way of knowing in cases (Hess and Mendelsohn 2010, Hess 2018). This perspective then resembles scholarship on the significance and meaning of maps and spatial reasoning in and through diagrams. Here, historical scholarship has long pointed beyond the idea of maps as accurate representations of territory, has emphasised the political and cultural dimensions of geographical maps (Harley 2002), and considered disease maps as “method of assemblage within which ideas are constituted and then argued about” (Koch 2011, 13).

The contributions to this special issue all engage with the curious combination of simplification and multiplication, that appears to structure most of existing scholarship on the topic so far. Following Nelson Goodman (1976), Laura Perini (2013: 274) explains that by comparison to other visual representations diagrams are “relatively non-replete” insofar as in diagrams “relatively few visible features are used to convey content”. And yet, if simplification may indeed be the case when it comes to some scientific diagrams, it cannot be said to be an inherent characteristic of diagrams as such. Indeed, to return to Chajes’ work, diagrams may be employed explicitly so as to complicate a simplified image of the world. Hence the Trees of Life deriving from the sixteenth century Lurianic school of the Kabbalah [Figure 2] are “kaleidoscopically multiplied” by comparison to earlier diagrams, such as the one examined above. Based on a more “spatial-mechanical” cosmology of emanation, which saw “higher levels of divinity [...] transposed and

expressed in the lower levels”, Chajes (2016) argues, Isaac Luria’s system “ma[de] diagrams more essential than ever to the aspiring kabbalist”.

Figure 2 HERE

When examining “working with diagrams” it is worth considering how different aspects of diagrams work, or how they can be deployed and transformed in ways that work. To what extent, for example, is the diagram’s graphic form essential to its working or being workable? In some cases, like the Kabbalistic trees of life, form can be of the essence and cannot be substituted (as Sefirot are drawn as circles in order to represent their true spherical nature). In other cases, form can be both symbolic and conventional, but is not ontologically tied to the diagram. Take for example diagrams of zoonosis where animal to human infection is represented by arrows; these are on the one hand conventional, in the sense that arrows generally convey causal relations in the sciences, but also symbolic insofar as pestilence has been represented both in narrative and visual sources in the form of arrows from the Iliad through to the Counter-Reformation (Lynteris 2017). And yet, if in the case of the Kabbalah a diagram that does not represent spheres would not work as a Tree of Life, in the case of epidemiology a diagram that does not employ arrows can still represent animal to human infection. If working with diagrams requires at least at a minimum level an ability of a human subject to transform and revise these diagrams to fit new situations, then that subject has to know the ontological value of the components of the diagram, or risk ending up with a diagram that no longer works.

This does not, however, mean that to work with diagrams means one have to necessarily end up with them. In fact, sometimes the aim of diagrams is precisely to produce something non-diagrammatic. Take for example the case of Marcel Baltazard, the renowned Pasteurian who, after establishing himself as a forerunner of the scientific investigation of plague in Morocco, founded his own regional Pasteur Institute in Tehran (Mainbourg 2007). There, in the 1950s, he directed far-reaching research in sylvatic plague, especially in Iran's Kurdish areas. Visually apt (he was an avid photographer and produced one film on plague which is today appreciated as a unique visual document of Iranian architecture), at some point he seemed keen to develop a popular means of communicating to the public plague's various transmission pathways. What he produced was a beautiful single-paged comic strip titled "Propagation of Plague in Iran's Kurdistan" [Figure 3] that predates today's movement of "graphic medicine" (Czerwicz et al 2015) by half a century.

Figure 3 HERE

The comic strip shows a merion rodent dying of plague, with its fleas then abandoning its cold cadaver so as to infest other rodents and eventually a turban-wearing bearded man, who appears to be scratching in evident irritation. The same man then develops first bubonic and then the contagious pneumonic form of plague, infecting his friend who in the last frame appears to be infecting another man by means of a transfer of human fleas.

What lied behind this uniquely legible piece of public health communication was a far more messy and ungainly diagram [Figure 4]. There the protagonists of the comic strip still are but schemas and names, and the jumps of the fleas rough, hand-drawn arrows between them. Though we lack the details and even the context of the process, one thing is clear: here the work of the diagram is achieved by its transformation into a non-diagram: a comic strip used for public health campaigns.

Figure 4 HERE

It cannot be stressed enough at this point that the “work of diagrams” cannot be limited to the work of their graphic elements as these only work within specific non-graphic contexts. The most important or at least immediate of these is the surface on which diagrams are drawn. John Bender and Michael Marrinan (2010) have noted the importance of the white surface is some of the defining diagrams of modernity: the ones adorning the pages of Diderot’s *Encyclopedia*. Discussing the plate on patisserie engraved by Robert Benard (“Pâtisier, Tour a Pate, Bassines, Mortier &c), the two authors stress the lack of volume in the figures of bowls, spoons etc., which synthesise what we may call a meta-diagram of patisserie. The “notation” of this diagram is in this case underlined by the lack of shadows on the white background of the figures. “This whiteness”, Bender and Marrinan (2010: 23) note, “is an arena of potentiality that fosters connections without fixing them or foreclosing thought experiments”. It is a whiteness that by “permeat[ing] the plates of the *Encyclopedia*” becomes “the field of Diderot’s *rapport* that we call correlation”: “We take it [to] be a virtual space whose material

presence – which joins together the disparate parts of the *Encyclopedia* plates – provides support for the composite play of imagery and cognition that is the motor-energy of diagram” (2010: 23). Writing about epidemiological diagrams describing animal-to-human infection (zoonosis) in the twenty-first century, Lynteris (2017) has noted the still pervasive operation of the blank background: “we need to consider the relation between geometric and iconographic components (lines and figures) of the diagram and its surface as a meaningful one; indeed, as a relation whose apparent invisibility is an important analytical component of its articulation”. Lynteris follows Kenneth Knoespel (2002) in arguing that the work of the blank surface is that it allows the double operation of diagrams hinted by their meaning in Greek: to both draw and erase (*diagrapho*). At one and the same time providing a surface for drawing the interrelation between significant components of zoonosis and erasing the ecological and social context of the latter, the white/blank surface of epidemiological diagrams makes infection appear as an objective process free from environmental or historical referents.

But the dialectic between the *diagrammatic* and the *diagraphic* (i.e. erasing) work of diagrams is not limited to their oft-used blank/white background. In her examination of kinship trees as “diagrammatic pilots of anthropological reasoning” (Lynteris 2017: 463), Nurit Bird-David challenges us to consider how they “dis-work – in ethnographic accounts of other peoples’ worlds”. “Do these diagrammatic tools”, Bird-David asks, “make fieldwork and its findings ‘intelligible to others’ – or, rather, to the contrary, in some cases *obscure* locals’ lived-worlds and the fieldwork process?”. The focus of Bird-David’s essay is small-scale societies and hunters-gatherers of South India in particular. Stressing the importance of the scalar context, Bird-David begins by interrogating the

impact of mapping in anthropological accounts of and relating with other peoples. Following Alfred Gell (1985) in stressing the non-indexicality of maps, Bird-David reflects on her own cartographic practices during fieldwork in the Nilgiri region culminating in the commissioning of a map of her field site; a map that whereas “demarcat[ing] a territory that the foragers are described as living *in*” crucially erased what in the forager’s experience is far more crucial, i.e. “*with whom* they [live]”: “not so much in space/system (environment, nature) but in a community of sentient beings with or alongside who they live”. Similarly, Bird-David argues, like the map can show us the *in* but obscures the *with whom*, the “kinship tree has its virtues” but also carries with it a work of erasure or obscuration. Bird-David reflects on how this is brought about by reflecting on W. H. Rivers’ much adhered-to instructions of collecting kinship data and drawing kinship diagrams (Rivers 1968). She identifies three key problems with this. First the fact that “Rivers’ method is rooted in using personal names” as these if where concrete bases for genealogical sorting, whereas in her ethnographic experience they are impermanent, “shaky basis for making pedigrees”. “A second problem” with Rivers’ diagrammatic protocol or “instructions”, Bird-David tells us, “was basing the method on father, mother, child, husband and wife relations”. Reflecting a nuclear-family-led bias of kinship, this ignored that for societies like the Gorge foragers it is siblingship which is the primary relation. Third, Rivers’ stress on “known status” (marriage, number of children) obscured the “performative basis of kinship relations” or what Bird-David aptly terms the “the minute work of ‘relating’ that constitutes relations” amongst foragers. The three problems with Rivers’ genealogical instructions are both reflected in and complicated in actually drawn kinship diagrams. Examining how following these instructions led her to

robust but prejudiced diagrams, Bird-David begins by noting that, “kinship diagrammatic tools embody a grammar of self and relations that obscure the forager sense of themselves and their community”. While showing connections, kinship diagrams emphasise individuals as nodal points while reducing the actual object of their graphic work, the connecting lines, to “add-on relations” of usually dyadic nature. This, Bird-David, stresses draws out an ontology that has no bearing with the “foragers’ primary sense of an intimate community into which one is born as a relative who is multiply connected to everyone else”. The *diagraphic* work of diagrams in this case can thus be said the erasure of the Gorge forager “performative and strategic kinship experience” that “Each person is at once relative(s) of multiple others”.

Reflecting “on the power and dangers of diagrams as a mode of anthropological exposition”, Matei Candea’s contribution to this collection turns its attention to the meaning and work of “graphic coherence”: “When is a diagram coherent? And what is it supposed to be coherent with?” Assuming a “practitioner’s view of the question of working with diagrams”, Candea explores “where and to what effect diagrams accompany, prefigure and exceed textual forms of anthropological argument”. To do this, he compares diagrams with another neglected anthropological practice: the use of algebraic formulations. Both forms of non-textual description in anthropology have been criticised as problematic, both for their lending of a (pseudo)scientific authority rigour to non-scientific statements, and for doing little more than repeating textual context. And yet, Candea argues, there is a key difference between the work of diagrams and that of algebraic formulations in anthropology. By contrast to mathematical notation, as a visual form diagrams are conceptually and indeed symbolically replete: “Circles imply closure

and perfection; unbroken lines seem to suggest that objects have firm boundaries”, etc. As inherently polysemic visual forms positioned between “visual excess” and “visual coherence”, diagrams, Candea tells us, require a textual reference or aid, so that they may be read. Although this position by Candea runs against most current cognitive and epistemological studies of diagrams, it is important to consider here the “work” diagrams perform in the text-oriented context of anthropology. Could the dependence of diagrams on texts in anthropology account for their relative lack of success both inside and outside the discipline? When read alongside other contributions to this collection, Candea’s reflections on anthropological diagrams challenges us to consider the extent to which, in some cases, diagrams may indeed become so linked to texts that they surrender their diagrammatic properties so as to work together with texts, and thus deliver a creative disturbance “at the intersection of convention and invention”. Cutting across (but perhaps not challenging) the iconophobic bias of the discipline, anthropological diagrams-with-texts work towards new concepts on the basis of “a self-conscious play with conventional visual languages”.

If Vidler (2000: 17) is right in that, in the digital age, “the diagram becomes less and less an icon and more and more a blueprint” we may ask here how this shift is already predicated in the work of what we may call transformational diagrams, such as epidemic maps or Conrad Waddington’s epigenetic landscape. Just like the model, the diagram suggests a change of medium, when it takes part in the scientific elaboration of a research object (Rheinberger 2015). And like the model, any diagram presupposes the transition from traces to data to then enable the tinkering with data-configurations. In early epidemiology, as Engelmann argues, the diagram’s configurations produce and

sustain the conceptual understanding of epidemics as configurations. The spatial diagram supported efforts of boundary work, to bolster epidemiology's "notions of complexity, to preserve system-thinking" against the deductive principles of the laboratory. With Ljungberg (2016, 142) the spatial diagram is an instrument of hybridity that not only represents and abstracts networks of relationships, but it allows for the experimental discover of new relationships and unknown elements. Engelmann thus demonstrates how spatial diagrams were used to open the frame for exploration of the unusual, unexplained dimensions of an epidemic, contrary to the common misunderstanding of a diagram as condensation of that which is known. To this end, Engelmann presents two maps produced to grasp the configuration of bubonic plague, first during an outbreak of the disease in the Russian village of Vetlianka (1878) and second during the 1899 outbreak in the Portuguese city of Porto. Engelmann compares the map produced in the former, as a diagram drawn ahead of the identification of plague's pathogen, with one produced after this watershed moment in the history of the disease. He thus demonstrates the persistent commitment of epidemiology to conduct inductive surveys rather than deductive investigations. As the contribution shows, this scientific ethos is sustained through diagrams. Here where the radical epistemological indeterminacy of induction as hallmark of epidemiological reasoning comes into focus, and Engelmann argues that through the working of epidemiologists with diagrams has the modern understanding of the epidemic as abstract object, as conceptual entity first emerged.

In her paper for this collection, Caroline Humphrey returns to Daston and Galison's idea of the "working object" (1992) in order to examine the defining image-object of epigenetics: Conrad H. Waddington's much-discussed "epigenetic landscape"

diagram. Humphrey poses a key question as regards scientific diagrams: to what extent can they be said to be “illustrations” of scientific theories, hypotheses or observations? Defining illustration as “a representational visual example of something, an image that uses naturalistic artistic means to make that object or idea clear and vivid”, she notes that what usually distinguishes diagrams from the former is that their work is not so much representational as explanatory or indeed “constitutive”. However, Humphrey asks, when one examines what following Isabelle Stengers (1987) we may call the “nomadic” work of Waddington’s epigenetic landscape diagram, the question about what makes this so adaptable and indeed inspirational across many different disciplines and fields arises. The answer, she claims, may be sought in the “illustrative character” of Waddington’s diagram, which by depicting a scene “require[s] the viewer to imagine the completion of a process about to take place in it”. This leads Humphrey to examine how the “visual and conceptual affordances of these diagrams, can set off a process of imaginative ‘work’ in a new field”. Thus going beyond both cognitive and epistemological discussions of diagrams, Humphrey’s paper seeks to elucidate the importance of the imagination (understood in the strong Castoriadean sense of the term, as a creative faculty) in the work of diagrams. Examining “the varied affordances of the diagram as a working object”, Humphrey’s paper proposes that “diagrams can perhaps best be seen as a *means of transportation* of a set of ideas from one context to another”. But both the transformational and transportational capacity of diagrams, Humphrey stresses is not an unconditional trait of diagrams as such. Rather it has to do with the way in which different diagrams embody relatedness or “the relations between parts”. If for some diagrams, opting for openness, this remains a both a constitutive and transformable

faculty, for others relatedness is fixed or over-specified, resulting in a loss of their “imaginative potential” – these are “overdetermined” diagrams that no longer entice the viewer to imagine, but instead instruct her or him “what to think”.

“Working with Diagrams” thus introduces scholarship that addresses the ephemeral dimensions of scientists’ interactions and collaborations with diagrams. Moving beyond these diagrams as mere inscriptions of objects and processes, we propose here an evaluation of diagrammatic reasoning as the work that is carried out with, on and beyond diagrams. The reasoning curated in this collection can be considered diagrammatic as it is invested in the production, the mobilisation as well as the repurposing and the annihilation of diagrams. “Working with Diagrams” brings together then for the first time a series of papers concerned with practices and studies that highlight the significance of diagrammatic reasoning in the sciences, indifferent to any visibility or material trace of a diagram.

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